

## CLAIMS

What is claimed is:

1. A process for preparing a noble metal catalyst comprising providing a solution of a platinum reagent containing platinum having a valency less than (IV); adding an oxidizing agent; providing treated particulate carbon; introducing said particulate carbon into said platinum reagent solution; and contacting said platinum reagent solution containing said particulate carbon with a precipitating agent.
2. The process of Claim 1, further comprising, prior to providing said treated particulate carbon, providing solution of a ruthenium reagent containing ruthenium having a valency less than (IV) and adding said ruthenium reagent solution to said platinum reagent solution.
3. The process of Claim 2 wherein said ruthenium reagent solution is added to said platinum solution at a rate greater than 0.3 millimoles per minute.
4. The process of Claim 2 wherein at least a portion of said oxidizing agent is added to said platinum solution simultaneously with said addition of said ruthenium reagent solution.
5. The process of Claim 2 wherein said ruthenium reagent is selected from the group consisting of water-soluble ruthenium (III) species.
6. The process of Claim 2 wherein said ruthenium reagent is selected from the group consisting of ruthenium chloride, ruthenium nitrosyl nitrate, and ruthenium nitrosyl sulfate.
7. The process of Claim 3 wherein said ruthenium reagent comprises ruthenium chloride.
8. The process of Claim 1 wherein said platinum reagent is formed by providing an aqueous chloroplatinic acid solution and adding to said aqueous chloroplatinic acid solution sodium hydrogen sulfite to form platinum sulfite acid.
9. The process of Claim 1 wherein said platinum reagent is selected from the group consisting of water-soluble platinum (II) salts.
10. The process of Claim 1 wherein said platinum reagent is selected from the group consisting of platinum sulfite acid, ammonium tetrachloroplatinate (II), potassium tetrachloroplatinate (II), and water soluble platinum (II) phosphine complexes.
11. The process of Claim 8 further comprising adding to said chloroplatinic acid solution a suspension containing from about 0.001

weight percent to about 2.0 weight percent of dispersant or surfactant, based on the total combined weight of solids.

12. The process of Claim 1 wherein said oxidizing agent is selected from the group consisting of hydrogen peroxide, oxygen gas, organic peroxides, and ozone.

13. A noble metal catalyst comprising a particulate carbon support and from about 5 to about 95 weight percent particulate metal, said metal comprising platinum, said catalyst having a total agglomerate volume less than about  $2.4 \times 10^{11} \text{ nm}^3/\text{nm}^2$ .

14. The catalyst of Claim 13 wherein the amount of said platinum is from about 50 to about 90 weight percent of the total weight of said platinum and said carbon support.

15. The catalyst of Claim 13, further comprising ruthenium.

16. The catalyst of Claim 13 wherein said agglomerate volume is less than about  $1.65 \text{ nm}^3/\text{nm}^2$

17. The catalyst of Claim 13 wherein said carbon is treated.

18. The catalyst of Claim 17 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxygen gas, hydrogen peroxide, organic peroxides and ozone.

19. The catalyst of Claim 17 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxidizing acids.

20. The catalyst of Claim 19 wherein said oxidizing acid is selected from the group consisting of nitric acid, perchloric acid, chloric acid, permanganic acid, and chromic acid.

21. The catalyst of Claim 13 wherein said carbon support has an oxygen content from about 0.1 to about 5 weight percent, based on the weight of the carbon.

22. The catalyst of Claim 15 wherein the total amount of said platinum and said ruthenium is from about 50 to about 90 weight percent of the total weight of said platinum, said ruthenium, and said carbon support.

23. The catalyst of Claim 13 wherein the amount of said platinum is from about 60 to about 80 weight percent of the total weight of said platinum and said carbon support.

24. The catalyst of Claim 15 wherein the total amount of said platinum and said ruthenium is from about 60 to about 80 weight percent

of the total weight of said platinum, said ruthenium, and said carbon support.

25. A catalyst prepared according to the process of Claim 1, said catalyst comprising a particulate carbon support and from about 5 to about 5 95 weight percent particulate metal, said metal comprising platinum, and having a total agglomerate volume less than about  $2.4 \times 10^{11} \text{ nm}^3/\text{nm}^2$ .

26. The catalyst of Claim 25 wherein said catalyst comprises from about 20 to about 90 weight percent of platinum.

27. The catalyst of Claim 25 wherein said catalyst comprises from 10 about 60 to about 80 weight percent of platinum.

28. The catalyst of Claim 25, wherein said further comprises ruthenium.

29. The catalyst of Claim 25 wherein said agglomerate volume is less than about  $1.65 \text{ nm}^3/\text{nm}^2$ .

15 30. The catalyst of Claim 25 wherein said carbon is treated.

31. The catalyst of Claim 30 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxygen gas, hydrogen peroxide, organic peroxides and ozone.

32. The catalyst of Claim 30 wherein said treatment comprises 20 contacting said carbon with an agent selected from the group consisting of oxidizing acids.

33. The catalyst of Claim 32 wherein said oxidizing acid is selected from the group consisting of nitric acid, perchloric acid, chloric acid, permanganic acid, and chromic acid.

25 34. The catalyst of Claim 25 wherein said carbon support has an oxygen content from about 0.1 to about 5 weight percent, based on the weight of the carbon.

35. The catalyst of Claim 25 wherein the amount of said platinum is from about 50 to about 90 weight percent of the total weight of said 30 platinum and said carbon support.

36. The catalyst of Claim 28 wherein the total amount of said platinum and said ruthenium is from about 50 to about 90 weight percent of the total weight of said platinum, said ruthenium, and said carbon support.

35 37. The catalyst of Claim 28 wherein the total amount of said platinum and said ruthenium is from about 60 to about 80 weight percent of the total weight of said platinum, said ruthenium, and said carbon support.

38. A coated substrate comprising a substrate having coated thereon an electrocatalyst coating composition, wherein the electrocatalyst coating composition comprises an anode or cathode electrocatalyst comprising a particulate carbon support and particulate platinum having, 5 said catalyst comprising from about 5 to about 95 weight percent platinum and having a total agglomerate volume less than about  $2.4 \times 10^{11}$  nm<sup>3</sup>/nm<sup>2</sup>.

39. The coated substrate of Claim 38 wherein the substrate is an ion exchange membrane.

10 40. The coated substrate of Claim 39 wherein the ion exchange membrane is the acid form of a perfluorinated sulfonic acid polymer.

41. The coated substrate of Claim 39 wherein the substrate is a gas diffusion backing.

15 42. The coated substrate of Claim 38 wherein the electrocatalyst coating composition further comprises a binder.

43. The coated substrate of Claim 42 wherein the binder is an ion exchange polymer.

44. The coated substrate of Claim 38 wherein the electrocatalyst coating composition further comprises a solvent.

20 45. The coated substrate of Claim 38 wherein said carbon is treated.

25 46. The coated substrate of Claim 45 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxygen gas, hydrogen peroxide, organic peroxides and ozone.

47. The coated substrate of Claim 45 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxidizing acids.

30 48. The coated substrate of Claim 45 wherein said oxidizing acid is selected from the group consisting of nitric acid, perchloric acid, chloric acid, permanganic acid, and chromic acid.

49. The coated substrate of Claim 45 wherein said carbon support has an oxygen content from about 0.1 to about 5 weight percent, based on the weight of the carbon.

35 50. The coated substrate of Claim 45 wherein the amount of said platinum is from about 50 to about 90 weight percent of the total weight of said platinum and said carbon support.

51. A fuel cell comprising a coated substrate, wherein the coated substrate comprises a substrate having coated thereon an electrocatalyst coating composition, and wherein the electrocatalyst coating composition comprises an anode or cathode electrocatalyst comprising a particulate carbon support and particulate platinum having, said catalyst comprising from about 5 to about 95 weight percent platinum and having a total agglomerate volume less than about  $2.4 \times 10^{11} \text{ nm}^3/\text{nm}^2$ .

52. The fuel cell of Claim 51 wherein the substrate is an ion exchange membrane.

53. The fuel cell of Claim 51 wherein the ion exchange membrane is the acid form of a perfluorinated sulfonic acid polymer.

54. The fuel cell of Claim 51 wherein the substrate is a gas diffusion backing.

55. The fuel cell of Claim 51 wherein the electrocatalyst coating composition further comprises a binder.

56. The fuel cell of Claim 55 wherein the binder is an ion exchange polymer.

57. The fuel cell of Claim 51 wherein the electrocatalyst coating composition further comprises a solvent.

58. The fuel cell of Claim 51 wherein said carbon is treated.

59. The fuel cell of Claim 58 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxygen gas, hydrogen peroxide, organic peroxides and ozone.

60. The fuel cell of Claim 58 wherein said treatment comprises contacting said carbon with an agent selected from the group consisting of oxidizing acids.

61. The fuel cell of Claim 60 wherein said oxidizing acid is selected from the group consisting of nitric acid, perchloric acid, chloric acid, permanganic acid, and chromic acid.

62. The fuel cell of Claim 52 wherein said carbon support has an oxygen content from about 0.1 to about 5 weight percent, based on the weight of the carbon.

63. The fuel cell of Claim 51 wherein the amount of said platinum is from about 50 to about 90 weight percent of the total weight of said platinum and said carbon support.

64. The fuel cell of Claim 51 wherein the substrate is an ion exchange membrane.

65. The fuel cell of Claim 51 wherein the ion exchange membrane is the acid form of the perfluorinated sulfonic acid polymer.
66. The fuel cell of Claim 51 wherein the substrate is a gas diffusion backing.